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Abstract

DETERMINATION OF THE PLUTONIUM 240 CONTENT IN PLUTONIUM BY MEANS OF NUCLEAR EMULSION

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Plutonium isotope composition is an important parameter in a plutonium fuel cycle in thermal nuclear reactors. This paper describes an inexpensive method for the determination of small quantities of Pu 240 in concentrations above 0.1% in the plutonium fuel, which may be used when a mass spectrograph is not available. The method is applied to any binary mixture of transuranium elements with very different spontaneous fission half-lives. The half-life for spontaneous fission of even-even nuclides is in general smaller than that of even-odd isotopes of a particular element. The half-life for spontaneous fission of Pu 239 is $4,5 \times 10^4$ times longer than that of Pu 240. This phenomenon in case of binary mixture of isotopes, allows a method for determination of the composition provided that for a determined mass of the element the spontaneous fission activity can be measured. This activity may be measured by means of the neutron emission from the spontaneous fission or by measuring the spontaneous fission activity.

By means of a technique for discrimination development of nuclear emulsion which allows a perfect discrimination between fission and alpha particle tracks in nuclear emulsion (Ilford K0 type), it is possible to record only the spontaneous fission tracks in the presence of intense alpha particle background. A weighed amount of chemical pure plutonium, converted to nitrate, is transformed into a thin film of inert plutonium

oxide by means of the technique for preparation of thin films with alcohol-ether-colodium nitrate solutions and then heated in a oven at 600°C. The film suport is made of stainless steel or hard-melting glass.

The nuclear emulsion is put in contact with the thin film oxide according to the Pu 240 content for a period of up to 20 days. After processing and scanning, it possible to measure activities so low as to produce 70 fission tracks/cm^2 in 20 days. Such an activity corresponds to an amount of 0.0001 mg of Pu 240. In the plutonium oxide film of 0.1 mg/cm^2 it corresponds to the presence of 0.1% of Pu 240.

By comparison with a standard fission neutron source it is also possible to ascertain the Pu 240 content by means of B-10 loaded nuclear emulsion in samples which contain a mass of the order of 10 mg or more of Pu 240.

The isotopic content of the plutonium produced in a U-238 U-235 reactor depends on the irradiation time, neutron flux, conversion ration and fuel enrichement, for example a 0.715 per cent burnup of the total uranium yields proportion of plutonium isotopes 239, 240, 241 and 242 of 65.1, 15.3, 16.1, 3.5 per cent. The half-lives for spontaneous fission of Pu 242 and Pu 240 are, respectivelly 7 x 10^{10} and 1.25 x 10^{11} years. In cases of high burnup, when the content of Pu 242 is considerably high the additional measurement of the gamma activities is necessary to obtain the ratio Pu 240 to Pu 242, since their spontaneous fission activities were measured together.